

Hospitalization and Medical Evacuation of Army Personnel Due to Toxic Inhalational Exposure—Operations Iraqi Freedom and Enduring Freedom, 2001 Through Mid 2011

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BACKGROUND

Problem Statement

Following the first Gulf War (1991), concerns related to potential toxic inhalational exposures among military personnel were raised that remain unresolved. Similar exposure concerns during deployment have arisen as a result of current efforts, including military support of Operation Iraqi Freedom (OIF) and Operation Enduring Freedom (OEF). During these conflicts, extensive intermittent ambient sampling has been conducted at select locations within the US Central Command area of operations (CENTCOM AO)¹ and questionnaires aimed at documenting service members' environmental exposures while deployed have been completed. Some work has been done to characterize exposure to specific exposure events on a population level. However, research regarding the possible relationship(s) between deployment-associated toxic inhalational exposures and subsequent health outcomes is limited, due to the fact that quantitative, verifiable exposure information at the individual level is difficult to ascertain.

Potential Exposures

The current conflicts in Southwest Asia comprise the longest period of continuous armed conflict in US history. As a result, almost all US military personnel serving since 2001 have deployed in support of these operations,^{2,3} typically 12 months at a time, with many service members deploying multiple times. As a result, concerns regarding environmental exposures during deployment have been documented frequently by deployed service members.⁴ Helmer et al found that concern for poor air quality from burning trash, smoke from oil well fires, and sand/dust was documented in 34%, 20%, and 16%, respectively, of reviewed medical records.⁵ Air sampling conducted by the Department of Defense (DoD) in Southwest Asia areas of operation identified particulate matter (PM) as a major environmental exposure of concern.⁶ Deployment-associated sources of PM include fine sand and dust that was resuspended by strong winds or troop activities, exhaust from the engines of

heavy machinery (gas, diesel, turbine), the industrial landscape that is characteristic of some locales, and potentially toxic smoke from burn pits and fires.⁶ Concern regarding these population level deployment-related exposures, as well as uncertainty regarding the health effect of combined exposures has highlighted the need for deeper understanding of individual environmental exposure during deployment. Gaining this understanding is complicated by the fact that personal exposure experiences vary with the unit, their mission, and location. Further, there may be unplanned or accidental exposures not reflected in available aggregate sampling data.

Exposure Events

Large populations have potentially had inhalational exposures due to ambient conditions, localized sources (industry), unplanned events (releases/venting of toxic substances, fires), and activities such as waste management. Available sampling data indicate that measured levels are rarely of acute concern, but if sustained, may be associated with or contribute to chronic health effects. The availability of sampling data varies, with most available data reflecting ambient conditions, and minimal data available for unplanned incidents.

Burn Pits

In addition to naturally occurring, ambient PM, burn pits are being recognized as a contributing source of PM at many OIF and OEF deployment locations in Southwest Asia.^{4,7} Prior to 2010, burn pits were widely used as waste management tools at locations where more sophisticated methods of solid waste disposal (incinerators, reuse/recycling, containerized removal by contractors) were not feasible methods for trash disposal in the war-time environment. A burn pit is formally defined as:

an area, not containing...an incinerator or other equipment specifically designed...for burning of solid waste, designated for the purpose of disposing of solid waste by burning in the outdoor air at a location with more than 100 attached or assigned personnel and that is in place longer than 90 days.⁸

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14. ABSTRACT Following the first Gulf War (1991), concerns related to potential toxic inhalational exposures among military personnel were raised that remain unresolved. Similar exposure concerns during deployment have arisen as a result of current efforts, including military support of Operation Iraqi Freedom (OIF) and Operation Enduring Freedom (OEF). During these conflicts, extensive intermittent ambient sampling has been conducted at select locations within the US Central Command area of operations (CENTCOM AO)1 and questionnaires aimed at documenting service members' environmental exposures while deployed have been completed. Some work has been done to characterize exposure to specific exposure events on a population level. However research regarding the possible relationship(s) between deployment-associated toxic inhalational exposures and subsequent health outcomes is limited, due to the fact that quantitative, verifiable exposure information at the individual level is difficult to ascertain.					
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Open-air burn pit use is now minimized due to the potential for both short-term and long-term health effects.

In response to concerns regarding the possible health effects brought about or exacerbated by exposure to smoke plumes originating from burn pits during deployment, several research initiatives to examine potential associations have been conducted. The Armed Forces Health Surveillance Center, Naval Health Research Center, and US Army Public Health Command conducted a series of evaluations that found exposure to burn pits was not associated with incidents of or worsening prevalent respiratory health diseases. However, it was acknowledged that, in light of study limitations, further investigation is needed to establish a better understanding of the relationship between exposure and outcome.⁹ The Institute of Medicine* recently released the results of their study, *Long-Term Health Consequences of Exposure to Burn Pits in Iraq and Afghanistan*^{†,7} which, among other things, concluded that it is uncertain whether exposures to emissions from burn pits have caused long-term health effects. But the report also included:

...the committee's review of the literature and the data from JBB [Joint Base Balad] suggests that service in Iraq or Afghanistan—that is, a broader consideration of air pollution than exposure only to burn pit emissions—might be associated with long-term health effects, particularly in susceptible (for example, those who have asthma) or highly exposed subpopulations (such as those who worked at the burn pit).^{7(p114)}

Despite the current absence of definitive evidence citing a direct link between burn pit smoke exposure and long-term chronic respiratory conditions among OIF and OEF veterans, deployed military forces, following DoD policies, have been decreasing their reliance on burn pits.

Fires

Not surprisingly, significant fire events have been documented in the combat theaters of Southwest Asia. The impact on the environment included air pollutants that may have had potentially detrimental consequences on the respiratory health of exposed military personnel. One study conducted after the Kuwait oil well fires at the end of the 1991 Gulf War found a statistically significant positive association between the prevalence of self-reported exposure to the smoke and self-reported symptoms of asthma and bronchitis. That association did not hold when modeled exposure was assessed in conjunction with the same respiratory outcomes.¹⁰ Petrucci

et al found increased reports of respiratory symptoms (such as cough, shortness of breath, upper respiratory tract irritation) among Soldiers with potential exposure to the Kuwait oil fires, a phenomenon that mostly dissipated at redeployment.¹¹ More pertinent to the current conflict is the Al Mishraq sulfur fire that burned in Iraq for 3 weeks in June 2003. A retrospective cohort study indicated more self-reported respiratory symptoms on the Postdeployment Health Assessment, DD Form 2796 (administered within 3 months of the end of deployment), among exposed personnel but did not show an increase of chronic respiratory conditions in association with exposure to the smoke plume.¹²

Geological Dust

An analysis conducted by Englebrecht et al¹³ on air samples collected from the CENTCOM AO implicated geological dust as one of the 3 main pollutants in the environment. The samples of interest showed generally expected composition, both chemical and mineralogical, when compared to samples from the Sahara and desert regions of the United States and China. However, average mass and chemical concentrations of the CENTCOM AO samples used in the analysis are as much as 10 times greater than those seen in samples from 10 rural and urban sites in the US near to military bases with similarly dry climates. Notably, the levels detected during this sampling program's efforts regularly exceeded the 24-hour standards set by the US Environmental Protection Agency.¹⁴

Exhaust and Industrial Byproducts

The operational setting in Iraq is largely desert, and industrial in nature. Existing infrastructure sources that contribute to air pollution include oil, cement, and fertilizer industries. The terrain of Afghanistan is mostly rugged mountains and desert, and environmental conditions have been described as degraded. Coupled with inherent environmental stressors of war, including factors like exhaust from military vehicles/heavy machinery and chemicals released during explosions, the extent of PM generated from these sources is of major concern regarding the respiratory health of our service members while deployed.¹⁵⁻¹⁷

Identification of Exposures Using Disease and Nonbattle Injury Data

Acute, high level exposures would likely affect few individuals, but are typically not reflected by sampling due to their unplanned nature. While individuals may seek

*The Institute of Medicine is the health component of the National Academy of Sciences. It is an independent, nonprofit organization that works outside of government to provide unbiased and authoritative advice to decision makers and the public. Information available at: <http://www.iom.edu/About-IOM.aspx>.

†The Institute of Medicine final report is discussed in detail in the article on page 43.

HOSPITALIZATION AND MEDICAL EVACUATION OF ARMY PERSONNEL DUE TO TOXIC INHALATIONAL EXPOSURE—OPERATIONS IRAQI FREEDOM AND ENDURING FREEDOM, 2001 THROUGH MID 2011

Table 1. Distribution of in-theater (OIF and OEF) toxic substance exposures (DNBI) requiring hospitalization from 2001 through mid 2011.

Toxic Substance Exposure	Environment When Exposed			Total
	Training	On-Duty	Unknown	
Poisoning by ingestion of toxic substances	1	414	14	429
Poisoning by inhalation of toxic substances	0	95	5	100
Adverse systemic or skin reaction by contact with a toxic substance	11	45	0	56
Total	12	554	19	585

Source: DoD Standard Inpatient Data Records database
OIF indicates Operation Iraqi Freedom
OEF indicates Operation Enduring Freedom
DNBI indicates disease and nonbattle injury

Table 2. Population demographics of Soldiers hospitalized in theater due to toxic inhalation exposures from 2001 to mid 2011 (N=100).

Category	No.
Age (years)	
17-19	6
20-29	62
30-39	24
40-49	6
50-59	2
Gender	
Male	93
Female	7
Rank	
E1-E3	25
E4-E6	64
E7-E9	1
WO1-WO5	3
O1-O3	6
O4-O10	1
Component	
Active Army	67
Army Reserve	20
Army National Guard	13

Source: DoD Standard Inpatient Data Records database

the focus of this article is DNBI related to toxic substance exposures, particularly those that are inhalational in nature, which resulted in hospitalizations or medical evacuations from the combat theater from 2001 through mid 2011. Since medical visits which did not result in hospitalization are not included, the data does not reflect exposures which may have been less severe.

care, these occurrences have not been systematically evaluated. Disease and nonbattle injury (DNBI) is the term for an illness and/or injury that is not directly related to enemy action or participation in direct combat. Reporting of DNBI from deployed settings can be used to evaluate the frequency and nature of individual toxic inhalational exposures. They can include injuries and illnesses resulting from training or recreational activities or occupational and environmental exposures indirectly caused by military service. Throughout the history of US conflict, DNBI have contributed significantly to decreased force strength and operational readiness of our fighting troops.¹⁸⁻²⁰

In order to highlight the impact of environmental exposures on the individual Soldier across the US Army,

DATA SOURCES

The DoD Standard Inpatient Data Records database stores information regarding inpatient medical encounters within the military health system. The electronic records for all hospitalizations occurring during deployment were accessed through the Patient Administration Systems and Biostatistics Activity. The US Transportation Command Regulating and Command and Control Evacuation System (TRAC²ES) is a web-based data repository that stores information pertaining to all patient regulation and movement throughout DoD activities and locations.²¹ Specifically, TRAC²ES contains individual health-related

data necessary to coordinate the transition of personnel requiring medical evacuation from the operational environment to a location where specialized medical care can be provided.²² In-theater hospitalization data was reviewed to identify hospitalizations among active duty Soldiers due to toxic inhalation exposures between 2001 and mid 2011. External cause codes were reviewed and available records were further refined to identify additional information and need for medical evacuation.

RESULTS

Toxic Substance Exposure

Disease and nonbattle injuries related to toxic substance exposures are specified as one of the following 3 categories: poisoning by ingestion of toxic substances, poisoning by inhalation of toxic substances, or adverse systemic or skin reaction by contact with a toxic substance. The most commonly occurring subcategory is ingestion of toxic substances, followed by inhalation of toxic substances, then adverse systemic or skin reaction with a toxic substance. Table 1 shows the distribution for each toxic substance exposure category.

Hospitalizations

Demographics

The data for all US Army personnel with a history of OIF and OEF deployments between 2001 and mid 2011 were eligible for capture in the query for toxic inhalation-related hospitalizations and evacuations. A total of 100 such hospitalizations was identified. The distribution of population demographics for those hospitalizations is shown in Table 2.

Causes, Trends, and Theater Distribution

Specific causes (identified by ICD-9* codes in the primary diagnosis field) that attributed to toxic inhalational

*International Classification of Diseases, Ninth Revision

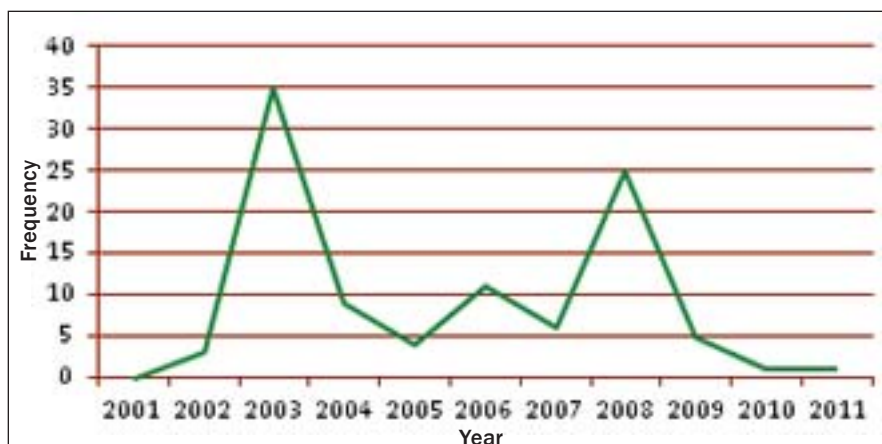


Figure 1. Yearly frequency distribution of toxic inhalation exposures requiring hospitalization (N=100) of Soldiers during Operations Iraqi Freedom and Enduring Freedom from 2001 through mid 2011. Source: DoD Standard Inpatient Data Records database.

exposures consisted mostly of toxic effects of gases, fumes, and vapors (not otherwise specified, n=22; not elsewhere classified, n=7), and toxic effects of chlorine gas (n=14). These diagnoses represent 43% of all toxic inhalational exposure hospitalizations (N=100). As shown in Figure 1, the frequency of toxic inhalational hospitalizations increased from 2001 through 2003, before decreasing and remaining fairly stable between 2004 and 2007, increased in 2008 before declining from 2009 through mid 2011. Operation-specific counts indicate the majority (n=91) of toxic inhalational exposure hospitalizations occurred in OIF, with 9 hospitalizations recorded from OEF.

Evacuations

Data gathered from TRAC²ES indicated 26 air evacuations from the combat theaters of OIF and OEF between 2001 and mid 2011 with toxic inhalational exposure listed as the cause of injury. The population demographics for those evacuations is presented in Table 3.

As shown in Figure 2, the frequency of evacuations for toxic inhalation increased from 2001 through 2004, decreased in 2005 before increasing and levelling between 2006 and 2008, then declined in 2009 and remained fairly stable through mid 2011. Theater-specific counts indicate the majority of toxic inhalational exposure evacuations were made from OIF (n=20), with 6 evacuations recorded from OEF.

CONCLUSION

Disease and nonbattle injuries have contributed significantly to overall morbidity and mortality associated with battle throughout the history of US conflict, and the current conflicts are no exception.^{18,20} Based on the available

data, poisoning by exposure to toxic substances, including toxic inhalations, is relatively infrequent. Some cases are serious enough to warrant in-theater hospitalization, a subset of which results in out-of-theater medical evacuation.

While deployed in support of OIF and OEF, our military personnel may experience toxic substance exposures that can have respiratory health consequences. Unfortunately, most of these exposures in the deployment environment cannot be avoided, and the demands of combat operations and wartime stressors may hinder adequate preventive measures.

While both the acute and chronic health effects of such exposures are not yet fully understood, studying such a relationship is difficult due to a lack of individual exposure data. Hospitalization and medical evacuation data related to toxic inhalational exposures were examined in an effort to better understand the extent of true exposure during deployment at the individual level in an objective fashion. Available data indicate that the number of toxic inhalational exposures significant enough to require hospitalization from 2001 through mid 2011 is small relative to the number of troops who were deployed and potentially exposed during that time period. A smaller subset of the hospitalized service members required medical evacuation due to severe inhalational exposures. As the data used in this study were limited to those toxic exposures significant enough to require hospitalization or medical evacuation, it represents some fraction of a still unquantified denominator that includes exposures that may have resulted in symptoms or medical evaluation, but not hospitalization. Additionally, toxic inhalation exposures may affect individuals with conditions which make them more

Table 3. Population demographics of Soldiers evacuated from theater due to toxic inhalation exposures from 2001 to mid 2011 (N=26).

Category	No.	%
Age (years)		
17-19	1	3.8
20-29	14	53.8
30-39	9	34.6
40-49	2	7.7
Gender		
Male	22	84.6
Female	4	15.4
Rank		
E1-E3	15	57.7
E4-E6	9	34.6
O1-O3	2	7.7
Component		
Active Army	16	61.5
Not annotated	10	38.5

Source: US Transportation Command Regulating and Command and Control Evacuation System

HOSPITALIZATION AND MEDICAL EVACUATION OF ARMY PERSONNEL DUE TO TOXIC INHALATIONAL EXPOSURE—OPERATIONS IRAQI FREEDOM AND ENDURING FREEDOM, 2001 THROUGH MID 2011

susceptible to exacerbations, such as asthma.²³ These hospitalizations would most likely be coded with the primary condition (asthma) and not the precipitating exposure. Therefore, while available data indicate that acute inhalational injury of significance is a rare event, this likely represents the “tip of the iceberg” of inhalational exposures while deployed.

The concern that the DoD has not truly identified the full impact of toxic inhalational exposures during military operations is not new, however. In fact, some personnel have received treatment due to environmental exposures during deployment, yet systems previously available have not captured this information adequately. As a result, some very specific solutions have been recently developed to improve the quality of the data collected when exposures result in medically notable encounters. These efforts include the establishment of the Defense Occupational and Environmental Health Readiness System-Incident Reporting module,* an official DoD archive system that includes fields for collection of incident data, personnel rosters, and medical/duty status; the institution of specific ICD-9 causal codes for consistent reporting and surveillance; development of base camp periodic occupational and environmental monitoring summaries and incident/hazard specific factsheets. Additionally, the US Army Public Health Command’s Environmental Medicine Program now offers an Environmental Medicine Clinical Consult Service, the only official environmental medicine level V support† offered through the Army Medical Command which provides documents and presents recommendations regarding diagnostics and/or medical documentation to address individual concerns associated with environmental exposures (see inset below). These tools facilitate more comprehensive

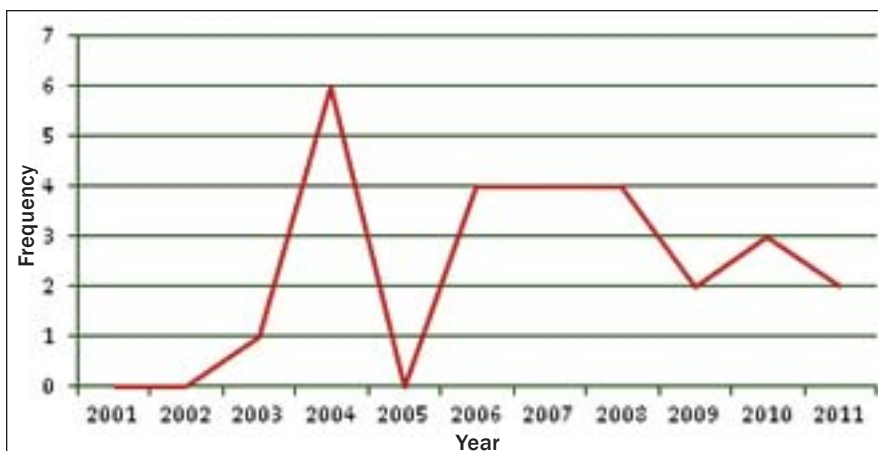


Figure 2. Yearly frequency distribution of toxic inhalation exposures requiring medical evacuation (n=26) of Soldiers from the combat theaters of Operations Iraqi Freedom and Enduring Freedom from 2001 through mid 2011. Source: US Transportation Command Regulating and Command and Control Evacuation System

evaluation, documentation, and reporting of toxic inhalational events and other environmental exposure incidents, and improve the DoD’s ability to address post deployment health concerns related to such exposures.

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*<https://doehrs-ih.csd.disa.mil/Doehrs/>

†Level V is support provided by the US Army Public Health Command and the Navy and Marine Corps Public Health Center. Responsibilities include, but are not limited to, supporting deployed level I – IV preventive medicine personnel; performing definitive testing of air, water, and soil samples; and performing vector pathogen testing.²⁴

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